

Report No. E6000-32  
Quarterly Report No. 11

ENVIRONMENTAL STUDY OF  
MINIATURE SLIP RINGS

George C. Marshall Space Flight Center  
Huntsville, Alabama 35812

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## ENVIRONMENTAL STUDY OF MINIATURE SLIP RINGS

### I. INTRODUCTION

This is the eleventh quarterly progress report on IITRI Project E6000, "Environmental Study of Miniature Slip Rings." This report covers the activities during the period 1 January 1966 to 1 April 1966 and is the third quarterly report on the twelve month continuation authorized by Modification No. 6 of Contract NAS8-5251. The objectives of the new effort are to evaluate slip ring materials and design techniques suitable for operation in high vacuum.

During the period reported herein, the following activities were performed:

- A. Lubrication studies in high vacuum have been started.
- B. Additional hard gold overlay studies have been carried out.
- C. A new brush design has been evaluated.
- D. Electroplating studies have been continued.
- E. Preparations for new run-in tests in high vacuum have been completed.

### II. REPORTING PERIOD ACTIVITY

#### A. Lubrication Studies

Apparatus for lubrication studies has been completed and installed in a high vacuum chamber. The high vacuum system employs an ion pump which eliminates any possibility of contamination from external sources. The test apparatus consists

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of a rotating shaft with a grooved copper-soft gold plated ring. A weighed piece of 7 mil brush wire is placed in the groove and attached to a microforce transducer. The lubricant is deposited on to the ring by evaporation and tested for its effect on friction, wear, and electrical noise. Shielding is provided to prevent the lubricant from contaminating the system. Figures 1 and 2 show the apparatus used in lubrication studies. Sixteen copper rings have been machined and plated with soft gold. The lubricant materials that have been chosen for testing are soft metals. The desired parameters are good wettability and low film cohesion. The candidate materials are: indium, rhodium, gallium, and chromium.

The first preliminary test runs and the calibration of the force transducer have been performed. During the first two runs several problems were encountered. One of the problems in using a free floating rider was that sticking would occur between the brush and the ring causing the rider to unbalance. This problem was solved by carefully balancing the rider and making several mechanical adjustments to insure that no vibration was being transferred to the ring from the driver motor, and that alignment was very accurate. Another problem was in perfection of the sublimation technique. During the first two runs, an insufficient amount of indium was deposited onto the rings. This involved a redesign of the indium crucible using a tantalum boat. During the first successful run, the slip

rings were rotated at 200 rpm with a 25 ma d-c current in the brush-ring circuit. The electrical noise averaged 5 millivolts in a vacuum of  $10^{-7}$  torr. The force on the transducer was 2.6 grams. Sublimation of indium was continued for ten seconds. The force on the transducer rose sharply to 7.9 grams and then came back immediately after sublimation to 2.1 grams. The noise dropped to an average level of 0.1 millivolts. After ten minutes of operation the force was 1.6 grams and the noise level was 1.2 millivolts. After seven hours the friction has increased to 4.3 grams. No noise measurement could be made since one of the wires internally connected to the ring had broken. The dramatic reduction of noise and friction immediately upon sublimation appears to be very promising. Further tests will be carried out with different candidate lubricants. The sublimation technique will be further improved to ensure a uniform deposition of the lubricant.

B. Hard Gold Overlay Studies

An attempt was made to perform a qualitative analysis of the organic constituents of the debris collected during a previous test of Autronex NI hard gold overlay. Spectrographic analysis indicated that there were no metals present in the debris. However, the amount of the debris was insufficient for a qualitative analysis. A run-in test has been conducted in a nitrogen atmosphere with a slip ring plated with Autronex NI hard gold overlay. The objective of this test

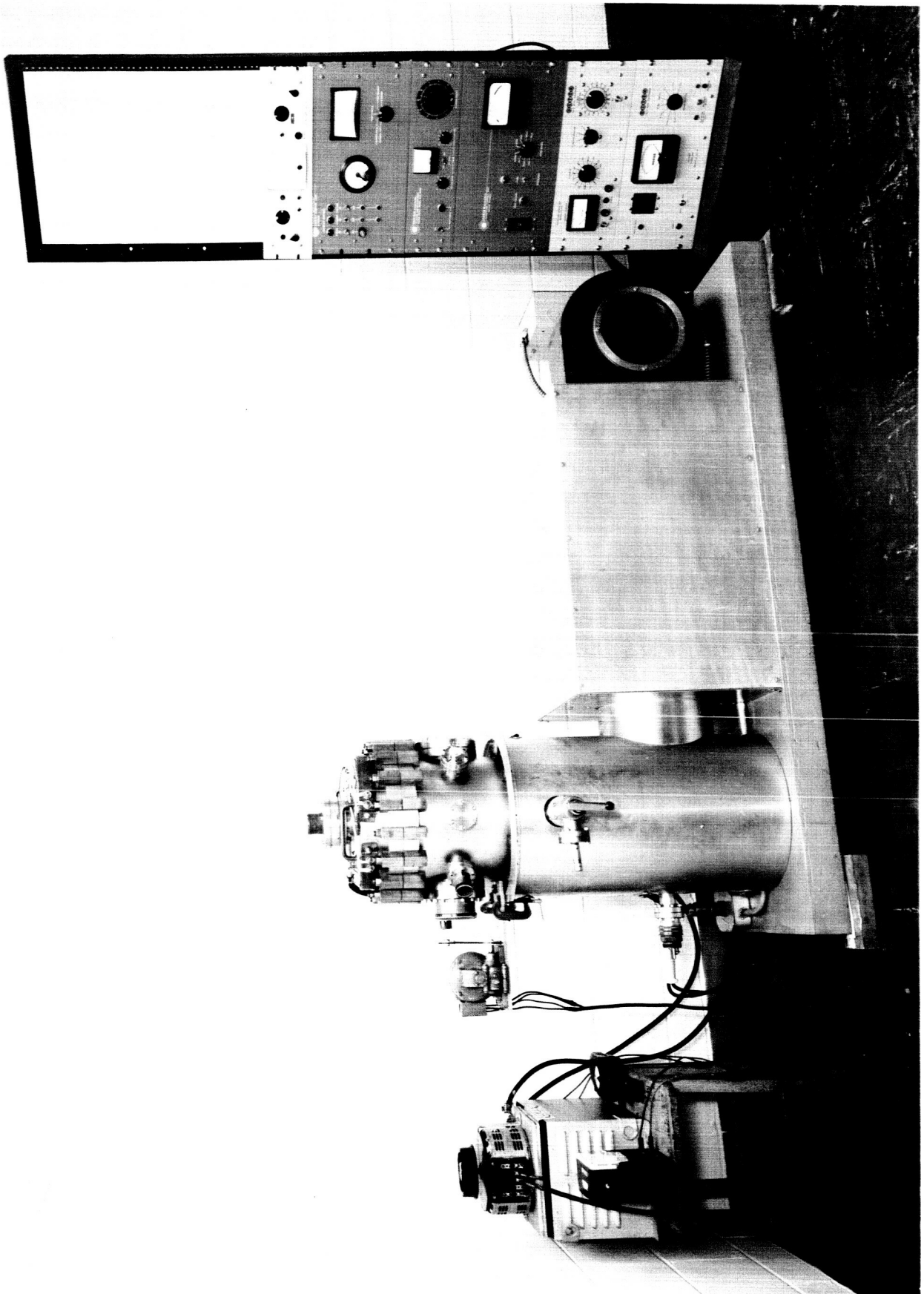


FIGURE 1 EQUIPMENT USED IN LUBRICATION STUDIES

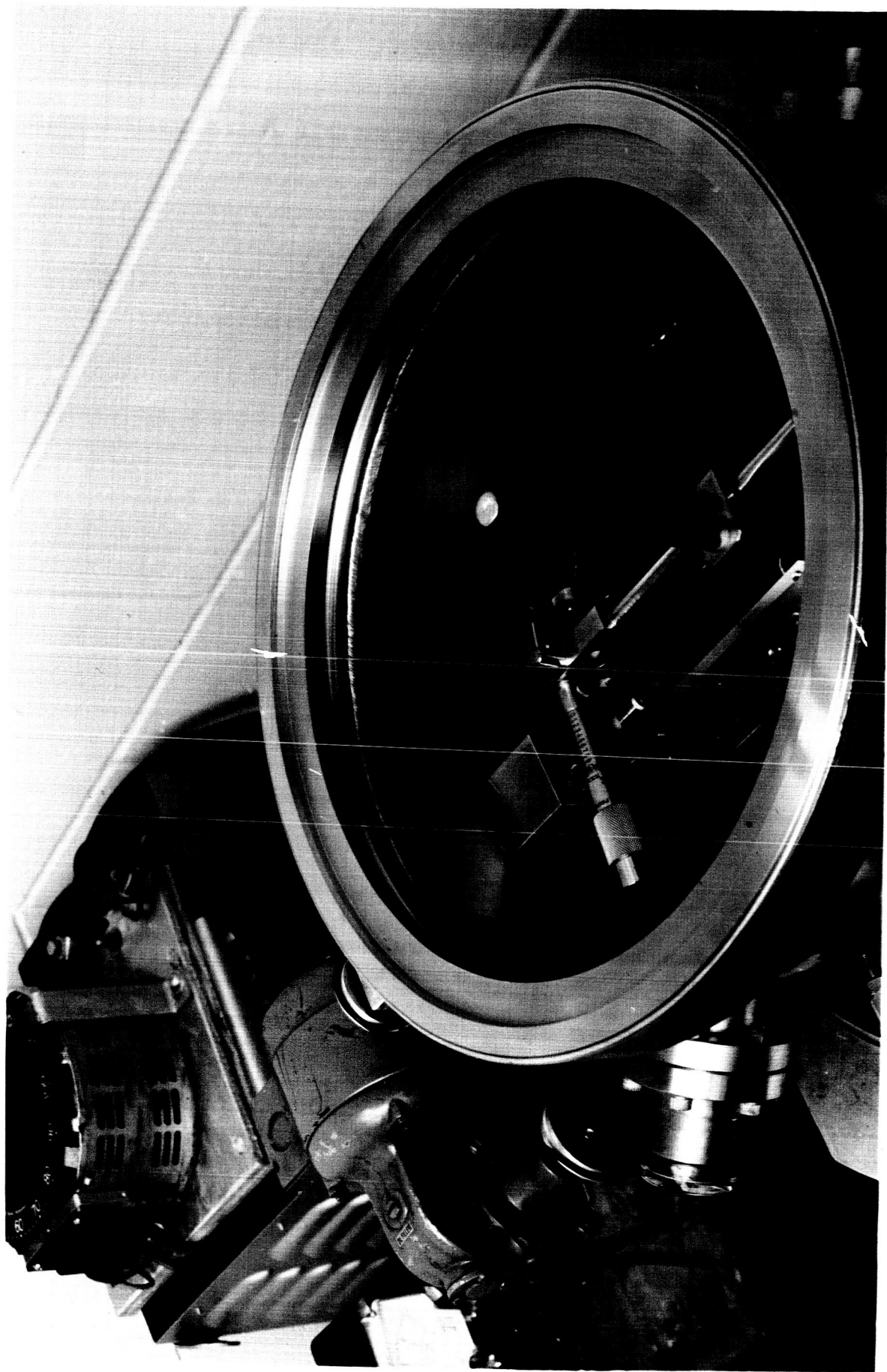


FIGURE 2 CLOSE-UP OF THE APPARATUS FOR LUBRICATION STUDIES

was to accumulate a sufficient amount of wear debris to enable a detailed spectrographic analysis. The run-in test was conducted for 840 hours of continuous rotation at 200 rpm with periodic and frequent reversal of the direction of rotation. A d-c current of 25 ma was supplied to the brush-ring circuit throughout the test. The noise level remained low with maximum readings of 400 microvolts peak-to-peak at the times of reversal of rotation. The average noise at the end of the test was 120 microvolts peak-to-peak. A sufficient amount of wear debris products has been collected and is being analyzed by spectrographic technique.

C. New Brush Designs

A new brush design has been evaluated both in a nitrogen atmosphere and in high vacuum. This design used a Nye-Oro 7 mil brush wire truncated along the axis with the resulting cord of the wire sitting in the ring groove. Both run-in tests indicated that there was no marked improvement in the noise performance as compared with the standard brush designs. Both tests were carried out for 280 hours of continuous rotation at 200 rpm with a brush current of 25 ma.

D. Electroplating Studies

Six copper rings have been machined to be used in electroplating studies. The objective of these studies is to investigate the effect of a relatively harder substrate under the hard gold overplating on wear and noise characteristics.



Previous experimental rings employed a soft gold basis metal for the overlays. Nickel, which has a well developed plating technology was selected as the candidate harder substrate material.

Electroformed nickel sleeves were deposited from a sulfamate-type nickel plating bath onto thin-wall cylindrical copper sheels. The sulfamate bath was selected for this study because the nickel obtained from such a bath possesses relatively low residual stresses. Specimens were plated at a current density of 144 amperes per square inch employing rapid rotation. Plating runs of 3 to 4 hours were required to build up the required thickness. The bath was operated at 45°C, and about 3.4 volts. The resultant deposits were lustrous, smooth, and showed a diamond pyramid hardness (DPH) of 285 under 100 gram loading.

E. High Vacuum Tests

Wear debris collected during two previous run-in tests in a high vacuum has been analyzed separately by the emission spectrograph. Both analyses revealed the presence of hydrocarbons of the cycloalkane or alkene type. It appears that complete elimination of contamination due to backstreaming through the diffusion pump is impossible in the presently used system. It was decided to carry out further high vacuum studies in a system employing an ion pump. This system consists of a five-inch diameter bell jar attached to a 25 liter

per second Ultek Boostivac pump with titanium sublimation on a water cooled jacket. The necessary mechanical modifications for mounting of the experimental capsule and the magnetic drive have been completed and the run-in tests will be started shortly.

F. Miscellaneous

Several items pertaining to high vacuum operation of sliding contacts appeared in literature. Lockheed Missiles and Space Company reported on a new brush material called CLB Alloy. Superior noise performance in high vacuum is claimed. Westinghouse Electric Corporation developed a new connector material for space applications. This material, niobium disellenide, can withstand high shearing action without any damage to the contact surfaces. Lectro-Dynamics developed a new lubricant for use in a vacuum. Exceptionally good properties are claimed for this lubricant. The above mentioned companies have been asked to supply more information and samples for our evaluation.

Two experimental brush-ring assemblies were fabricated and were forwarded to George C. Marshall Space Flight Center to be used in the in-house studies. One of the assemblies employed the presently used brush-ring design and the other assembly had an isolated ring as used in previous studies.

### III. SUMMARY

The results of the activities performed during the reported period can be summarized as follows:

- A. Lubrication studies in high vacuum have been started.
- B. A run-in test of a hard gold overlay was conducted in a nitrogen atmosphere and a sufficient amount of debris was collected for a spectrographic analysis.
- C. A new brush design was evaluated and no marked improvement in noise performance was found.
- D. Nickel - soft gold plated rings have been prepared to be tested in nitrogen atmosphere.
- E. Preparations have been completed for resumption of tests in a high vacuum using an ion pump system.

### IV. FUTURE ACTIVITIES

During the next quarterly report period of this program, the following activities will be performed:

- A. Lubrication studies in high vacuum will be completed.
- B. Spectrographic analysis of wear debris collected during the run-in test of a hard gold overlay ring will be performed.
- C. Run-in tests of nickel-soft gold plated rings will be conducted.
- D. Run-in tests of experimental capsules in a high vacuum will be carried out.

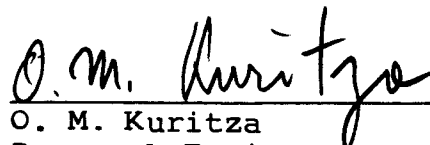
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V. PERSONNEL AND LOGBOOKS

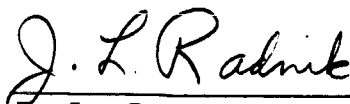
IITRI staff members who have contributed to the research effort described in this report are J. L. Radnik, W. H. Graft, R. G. Scholz, W. J. Courtney, M. Lerner, M. Holzer, D. F. Simonaitis, and O. M. Kuritza.

The data on this project are recorded in logbooks C15698, C14223, C14942, and C14069.

Respectfully submitted,  
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